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AUTHOR	Gober, Billy; Hill, Fred
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ABSTRACT

Two hundred and fifty-six children between the ages of five and eight years were tested for reaction time and movement time on an electrical device which was constructed by the author. Since the primary purpose of this project was to gather base-line data on the reaction times and movement times of these particular children, no specific conclusions can be offered. The data tend to support the following general conclusions about the sample tested: (1) there was an improvement in both reaction time and movement time with advancing age; (2) there was no sex difference in reaction time or movement time; and (3) there was a high degree of relationship between reaction time and movement time. (Author)

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Research Paper No. 26

PRELIMINARY REPORT ON REACTION TIME AND MOVEMENT TIME OF YOUNG CHILDREN

Billy Gober
Fred Hill

July, 1970

Research and Development Center in Educational Stimulation
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Prepared for the Physical Education Program of the
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INTRODUCTION

Reaction time should be of concern to physical educators and coaches since fast reactions are needed for any degree of excellence in most sports activities. Of equal concern should be the amount of time required to complete a response after initial reaction to a given stimulus (movement time). Since both of these measures develop through maturation, it would seem worthwhile to investigate the pattern of this development during the period of most rapid maturation--the early elementary school years.

PURPOSE

The purpose of this study was to gather base-line data on the variables of reaction time and movement time of children five to eight years of age who were enrolled at Arnold School and to determine how these measurements varied by sex and with advancing age. Also, the purpose was to determine if a relationship exists between these two measures.

RELATED LITERATURE

Reaction Time, Movement Time, and Age

Many studies have been done concerning reaction time and age. Philip (1934), in an extensive study of children from nine to sixteen years of age, reported a steady drop in reaction time with increasing age for four different types of response: sound with warning, light with warning, sound unprepared, and light unprepared.

Goodenough (1935) tested 246 children ranging in age from 3-1/2 to 11-1/2 years old and 56 college students for simple reaction time to an

auditory stimulus by the use of a Miles Reaction Time Board. This timer required the subject to press down on a key at the presentation of the stimulus. She reported continued decrements in reaction time with age and also increased control over the motor act.

To determine if the length of the peripheral nerve path had any effect on the slowing of reaction time with age, Birren and Botwinick (1955) tested thirty-two young subjects between the ages of eighteen and thirty-six years and thirty-two elderly subjects between the ages of sixty-one and ninety-one years old for simple reaction time of the finger, jaw, and foot. They found the reaction time of the elderly subjects to be significantly slower than the younger subjects, but found no relation between reaction time and the length of the peripheral nerve path involved.

Bellis (1933) studied the reaction times of subjects ranging from four to sixty years of age to both an auditory and a visual stimulus. He reported continued decrements in reaction time until about age thirty and then a gradual increase with age. The number of subjects in each ten-year span was ten males and ten females which could hardly be classified as a sufficient number to be representative of that age group. Bellis does imply that a relationship may exist between the curve of reaction time and the curve for mental growth.

An extensive study by Pierson and Montoye (1958) compared the reaction times and movement times of 400 male subjects between the ages of eight and eighty-five. They reported that both reaction time and movement time are significantly related to age, although in neither case does a simple mathematical equation express this relationship. The fastest responses were recorded in the early twenties and consistency of response was greatest at about thirty years of age.

Atwell and Elbel (1948) report continued small increases in speed of response up to age seventeen, which was the oldest age used in their study.

Miles (1931) also reports low but significant positive correlations between age and speed of reaction using three different kinds of response for subjects twenty-five to eighty-seven years of age.

Mendryk (1960), comparing three different age groups, twelve, twenty-two, and forty-eight years old, found reaction time and movement time to be unrelated to age for the 150 subjects he tested.

Overath (1967) found that reaction time of children six to twelve years of age decreased with age, but found significant changes in movement time for only one age group.

Although the literature concerning the relationship of movement time and age is not enormous, it would seem that movement time does vary with age with some question about this variation in young children. There is greater evidence that reaction time does vary with age. One of the contributors to this evidence has done more recent research which might cast a shadow of doubt on this evidence. Botwinick and Thompson (1968), in a study comparing the heart rate and reaction time of elderly and young subjects, report some interesting facts that their investigation did not set out to find. They subdivided the group of young subjects into those who exercised regularly in some form of athletics and the nonathletes. The athletes varied significantly from the elderly in reaction time. The nonathletes did not vary significantly.

Although the number of subjects in the study was small, the implications are apparent. It has always been thought that the variation in

reaction time with age was a function of changes within the central nervous system. Perhaps the changes within the central nervous system and the degree of muscular fitness are co-functions of the variation in reaction time with age. The indication is that more research is needed with groups subdivided by degree of muscular fitness.

Reaction Time, Movement Time, and Sex

Several of the studies mentioned in the previous section compared the measures by sex. Philip (1934) reported that boys were significantly faster than girls for all responses except light with warning. There is a definite retardation of reaction time of adolescent girls which is not apparent in adolescent boys.

Goodenough (1935) also reported a slight sex difference in favor of males.

Bellis (1933) found the average reaction time of males to be less than for females. This was especially apparent in childhood and late maturity. The mean reaction times most closely approximated each other in the thirty-year-old group.

Seashore and Seashore (1941), in studying the speed of response of the hands, feet, and jaws, found men to be significantly faster than women, especially after practice.

Only one study could be found that made a comparison of movement times by sex. Overath (1967), in a study of 210 elementary school children ranging in age from six to twelve, found boys to be significantly faster than girls in movement time.

Although the literature is not conclusive about movement time, it is apparent that males are faster than females in reaction time.

The Relationship of Reaction Time and Movement Time

Tuttle and Westerlund (1931), in a study of the relationship between running events in track and reaction time, found a high degree of relationship between speed in running the 75-yard dash and reaction time ($r = .863$). If speed of movement over a distance is considered a similar measure to movement time, this study would indicate a high degree of relationship between reaction time and movement time.

A study by Beise and Peasely (1937) supports the above findings for a group of college women.

In a later study by Youngen (1959), a statistically significant relationship was found between reaction and movement time when forty women athletes were compared with seventy-five women nonathletes.

An extensive study by Pierson (1959) of the reaction times and movement times of 400 male subjects between the ages of eight and eighty-three found a significant relationship between the two measures.

Henry (1952) measured the reaction and movement times of sixty college men on a ball snatch coordination test and forty-three men on a treadle press test. He reported that the reaction times and movement times of his subjects were independent and uncorrelated.

Slater-Hammel (1952) reported similar results. He tested twenty-five male college physical education majors on an instrument which involved the sideward rotation of the arm and shoulder through an arc of 120 degrees. He found no relationship between the reaction and movement times of the subjects tested.

In a study of the effect of body weight upon reaction time and movement time, Schafer (1968) found no relationship between the two measures for the twenty-five overweight and thirty normal women that she compared.

Overath (1967) also found no significant relationship between the reaction times and movement times of the 210 elementary school children that she tested.

Reaction times and movement times involved in short arm movement and long arm movement were studied by Mendryk (1960). He reported non-significant intercorrelations for measurements of the three age groups tested: twelve, twenty-two, and forty-eight-year-old males.

On the subject of the relationship of reaction time to movement time, the literature yields nothing but controversy. Four studies were found in which a significant relationship was reported and five were found that reported no relationship. The question remains unanswered.

Summary

From the literature, it would appear that there is a significant relation between reaction and movement times and age. Two extensive studies of reaction time of small children were found which reported decreases in reaction time with age. Other studies, not dealing particularly with this age group, reported similar results with a small number of subjects. Only one study was found dealing with the movement time of children below eight years of age. This study reported significant differences in movement time for only one of the age groups tested.

All of the studies reviewed on the relation of reaction time and movement time to sex reported a sex difference in favor of males.

Although the literature on the subject is extensive, no conclusions can be reached on the relationship between reaction time and movement time.

Reaction time and movement time appear to be two of the most researched psychometric measures, but there still remain many unanswered questions about relationships involving these two measures.

PROCEDURE

Apparatus and Method

One of the most important factors to be considered in an experiment of this type is the timing device or chronoscope. An investigation was made of the different types of chronoscopes from the Hipp model, which was probably the first reliable one, to the modern devices of intricate design. It was found that all of these devices, no matter how intricate, were subject to two types of constant errors. First of all, they were subject to terminal errors which are the result of lag in starting and overshoot in stopping. These errors are absolute and are independent of the interval measured. They may be compared to failure to line up an object with the marks on a yardstick when measuring length. Most chronoscopes are liable to this type of error. Secondly, they are subject to running errors which are the result of faulty speed of the running mechanism. These are relative and may be expressed as percentages of the interval measured. They are comparable to those introduced by a yardstick which has shrunk.

All of the chronoscopes studied,except two, were precision instruments and fairly expensive. One was suggested by Woodworth (1954) that costs essentially nothing, and has the advantages of portability, silence, and accuracy. He suggested that a stick, such as a yardstick or meterstick, be dropped in freefall and a subject be instructed to stop the fall of the stick on a given stimulus. The distance that the stick fell

could then be converted to time by the formula $S=\frac{1}{2}GT^2$, where S is the distance of the fall in millimeters or feet, G is the acceleration due to gravity (9800 mm/sec. or 32 feet/sec.), and T is the time in seconds. This method was used in a previous experiment by this investigator and found to be a fairly reliable method.

Another instrument which used the uniform acceleration of gravity has been suggested by Slater-Hammel (1954). He suggested that a small metal ball be held in place along some measuring device above the subject's hand. The ball would then be dropped from various heights until the subject could no longer remove his hand before the ball hit it. This distance could be converted to time by the previously mentioned formula.

A third method, which was used in some of the first reaction time experiments, was the use of a revolving drum with a tuning fork to construct a time line. At the presentation of the stimulus, a mark was made on the drum by a stylus and a second mark made at the response. The number of vibrations between these two marks was then converted to time.

The instrument constructed for this project was an electric device which makes use of two chronoscopes. Since the literature is filled with different versions of electric timing devices, this writer claims no originality for the device constructed. It was constructed with two goals in mind: to make it valid and reliable and to make it portable.

To meet the goal of portability, a wooden box, 18" by 18" by 11", was constructed so that the front and back panels folded down. The back panel contained the two clocks and the front panel contained the stimulus light, reaction switch, and lever for stopping the second clock. The

stimulus light and the two clocks were wired into a silent mercury switch which was mounted inside the box. A veil was dropped inside the box so that movements of the tester could not be detected by the subject.

The reaction time switch was a micro-switch which opened a circuit when a depressed lever was released. It was mounted in a switch box that could be moved to accommodate a right-handed or left-handed person. The release of the lever stopped the first clock. The distance from the edge of the lever to the lever which stopped the second clock was seven inches.

The lever which stopped the second clock was connected to a mercury switch and was sensitive to a one-fourth-inch downward movement of the lever. This lever was flexible and was mounted on a pivot point which connected to the switch. It could be slammed down hard or pressed easily with no loss of sensitivity.

The subject to be tested was seated in front of a table on which the box was placed and unfolded. He was instructed to place the index and middle fingers of his dominant hand on the reaction time lever and press down. His other hand was placed in his lap. He was told to concentrate on the stimulus light and, when it came on, to release the reaction time lever and to reach forward and press down on the plastic lever which stops the second clock.

The tester gave the signal, "ready", waited from one to five seconds and closed the switch which started the clocks and turned on the stimulus light. The subject then released the reaction time lever, which stopped the first clock, and then pressed down on the plastic lever, which stopped the second clock. The reading on the first clock was the reaction time

and the reading on the second clock was the total response time. Movement time was obtained by subtracting the reading on the first clock from the reading on the second clock.

Five measurements of reaction time and movement time were administered to each subject. The first two were administered in order to familiarize the subject with the instrument and procedure. The mean of the last three measures was taken as the reaction time and movement time of the individual.

Subjects

The subjects for the present study consisted of 256 five- through eight-year-olds attending Arnold School, Jonesboro, Georgia, during the school year 1969-70. The composition of the above mentioned sample was as follows:

Age	Male	Female
5	29	29
6	50	52
7	28	22
8	26	20

Statistical Treatment

Statistical treatment of the data consisted of an analysis of variance by age and by sex. A Pearson Product-Moment Correlation Coefficient was computed to determine the relationship between the two measurements.

RESULTS

An analysis of variance by age and by sex was computed for reaction time with results reported in Table I. An investigation of this table reveals a significant variation ($p < .05$) in reaction time between the different age levels but no significant variation by sex.

Table I

Analysis of Variance for Reaction Time: Age and Sex

Source	df	SS	MS	F
Modal	7	3,759.546	537.073	17.116
Error	248	7,781.762	31.378	
Age	3	3,472.802	1,157.601	36.892*
Sex	1	163.803	163.803	5.220
Age x Sex	3	51.494	17.165	.547
Total	255	11,541.309		

*.05

To further investigate the significant variation between the different grade levels, a Duncan's Multiple Range Test was applied. The results of this test reveal that five-year-olds (mean = .3650) and six-year-olds (mean = .3016) differed significantly from all other ages tested. Seven-year-olds (mean = .2748) differed significantly from five- and six-year-olds, but did not differ significantly from eight-year-olds. Likewise, eight-year-olds (mean = .2597) differed significantly from five- and six-year-olds but not from seven-year-olds.

Table II

Analysis of Variance for Movement Time: Age and Sex

Source	df	SS	MS	F
Modal	7	4,877.060	696.723	33.403
Error	248	5,172.799	20.858	
Age	3	3,900.575	1,300.192	62.335*
Sex	1	639.318	639.319	30.651
Age x Sex	3	287.432	95.811	4.593
Total		10,049.859		

*.05

An analysis of variance for movement time by age and sex was also computed on results reported in Table II. The results are similar to the results for reaction time. There was a significant variation in movement time between age levels but no significant variation by sex.

A Duncan's Multiple Test revealed that all four age levels (five-year-old mean = .3838, six-year-old mean = .3213, seven-year-old mean = .2996, eight-year-old mean = .2656) were significantly different from each other.

In order to determine the relationship between reaction time and movement time, a Pearson Product-Moment Correlation Coefficient was computed. The correlation between these two variables (r = .5726) was found to be significant at the .01 level of significance.

SUMMARY AND CONCLUSIONS

Two hundred and fifty-six children between the ages of five and eight years were tested for reaction time and movement time on an

electrical device which was constructed by the author. Since the primary purpose of this project was to gather base-line data on the reaction times and movement times of these particular children, no specific conclusions can be offered.

The data tend to support the following general conclusions about the sample tested:

1) There was an improvement in both reaction time and movement time with advancing age.

2) There was no sex difference in reaction time or movement time.

3) There was a high degree of relationship between reaction time and movement time.

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